

W Production in Polarized p-p Collisions: A Probe for Sea Quark Spin

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For the PHENIX Collaboration

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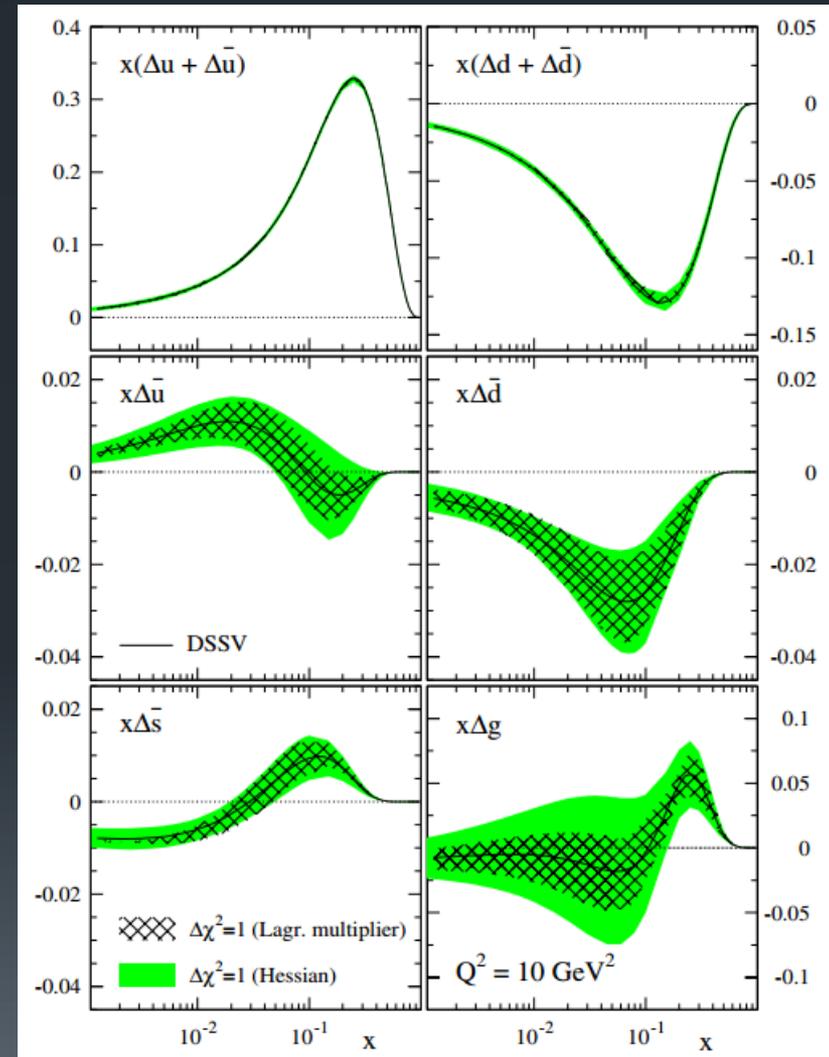


Outline

- Proton Spin Structure
- W Asymmetry Measurement
- PHENIX and RHIC
- Analysis and Initial Results
- 2013 Run Projections

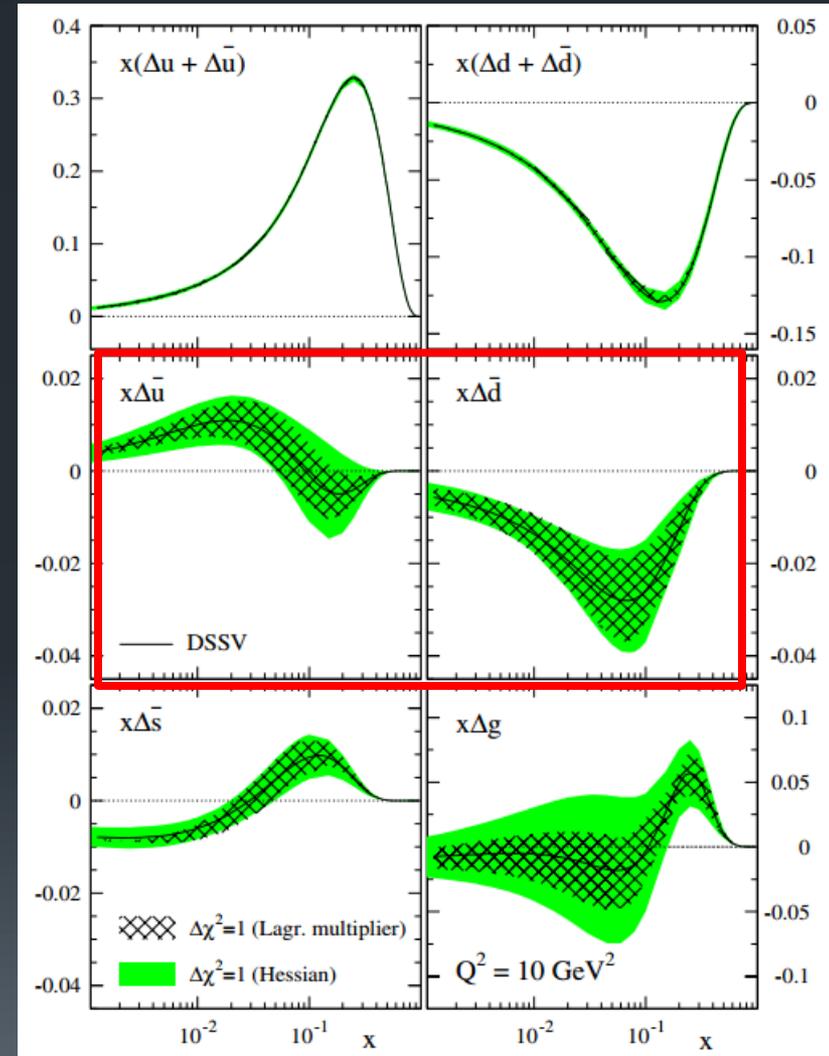
Proton Spin Structure

- Contributions to proton spin:
 - $S_p = \frac{1}{2} \Delta\Sigma + \Delta g + L$
- 20 years of DIS/SIDIS measurements
 - DIS: Sensitive to quark antiquark sum
 - SIDIS: Limited precision
- Recent work: pp collisions at RHIC



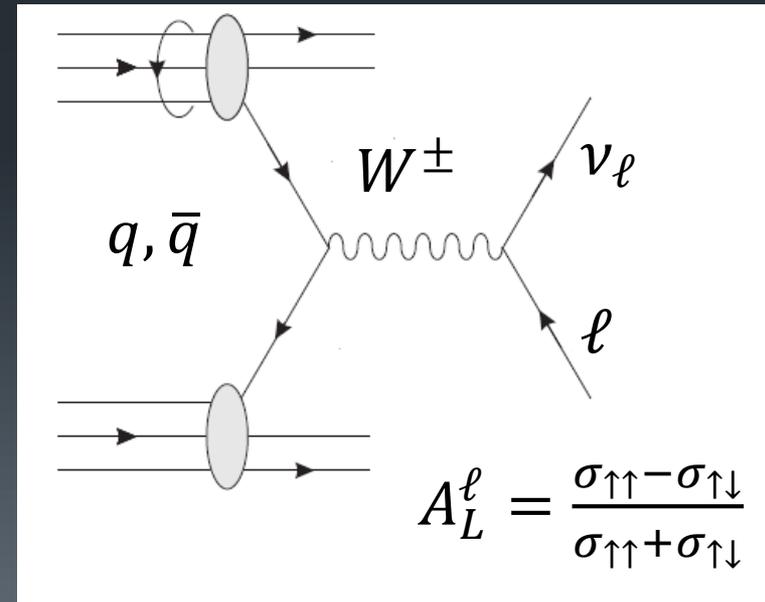
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- Recent work: pp collisions at RHIC
- Our measurement focuses on $\Delta\Sigma$, specifically $\Delta\bar{u}$ and $\Delta\bar{d}$



Sea Quark Spin: Using the Weak Interaction

- Study single spin asymmetry in production cross section of W bosons in polarized pp collisions at $\sqrt{S}=500$ GeV
 - Polarized proton beams with different possible longitudinal polarization orientations
 - W produced in Quark-antiquark annihilation decays into lepton/neutrino.
- Advantages:
 - High Q^2 (lower NLO sensitivity)
 - No dependence on fragmentation functions
 - More direct flavor and antiquark sensitivity



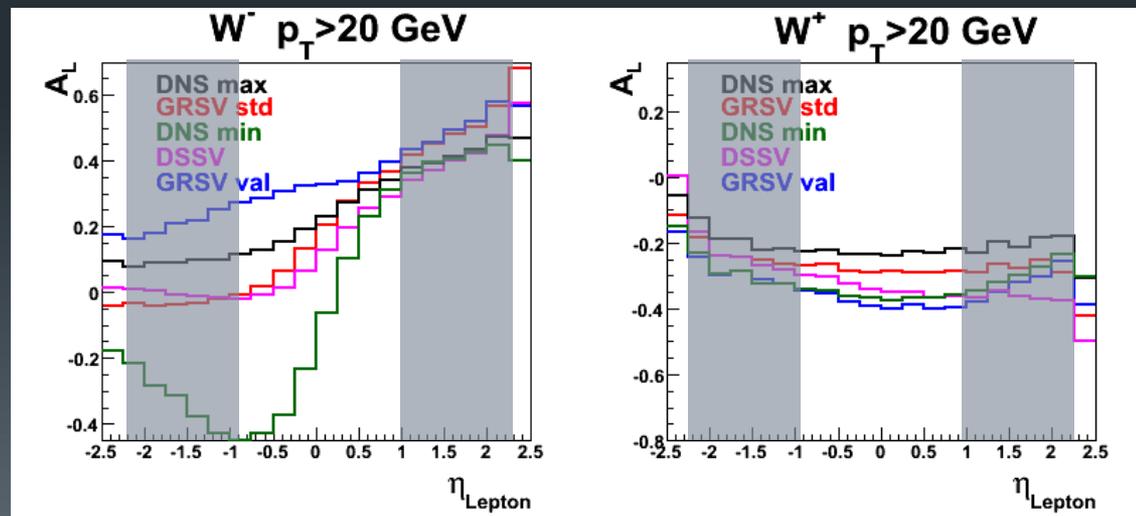
Single Spin Asymmetry in W Boson Production

- Observe $W \rightarrow \mu$ decay at forward rapidity
- Leading Order picture: flavor decomposition

$$A_L^{W^+} \propto \frac{-\Delta u(x_1)\bar{d}(x_2) + \Delta\bar{d}(x_1)u(x_2)}{u(x_1)\bar{d}(x_2) + \bar{d}(x_1)u(x_2)}, \quad x_1 \gg x_2 \Delta u/u, \quad x_1 \ll x_2 \Delta\bar{d}/\bar{d}$$

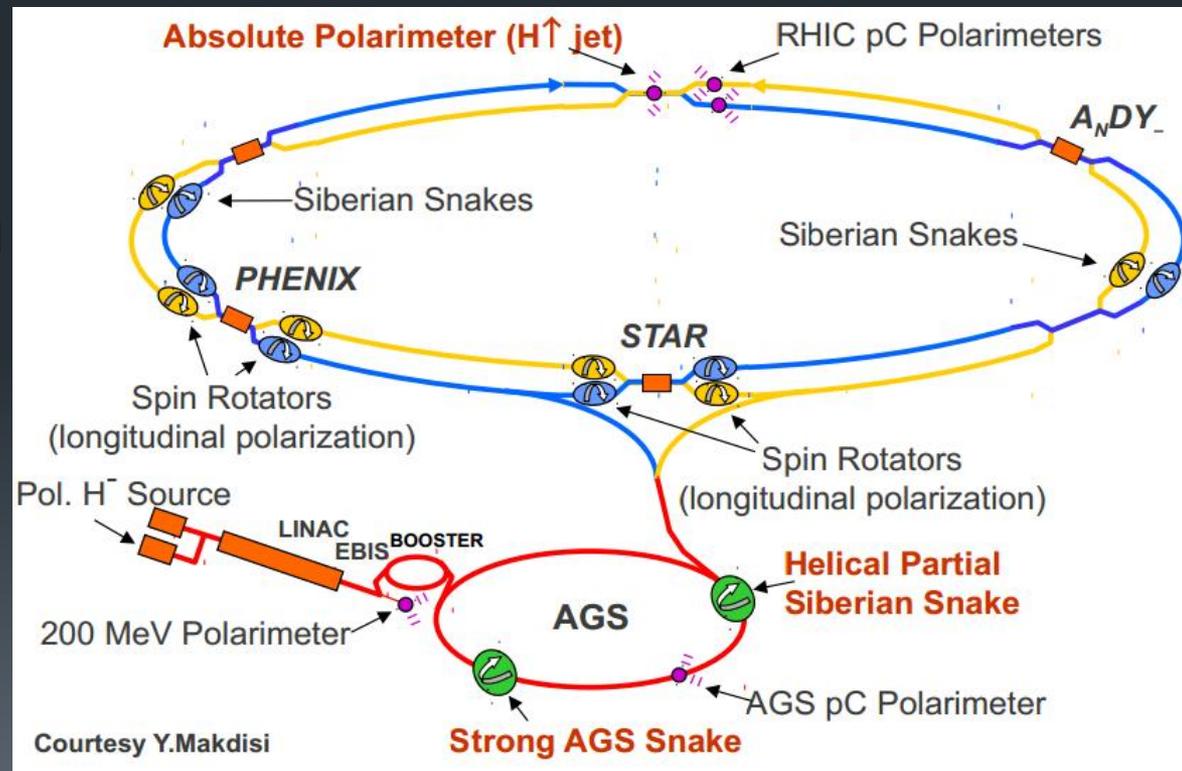
$$A_L^{W^-} \propto \frac{-\Delta d(x_1)\bar{u}(x_2) + \Delta\bar{u}(x_1)d(x_2)}{d(x_1)\bar{u}(x_2) + \bar{u}(x_1)d(x_2)}, \quad x_1 \gg x_2 \Delta d/d, \quad x_1 \ll x_2 \Delta\bar{u}/\bar{u}$$

- Simulations show the measurement remains sensitive even with NLO considerations



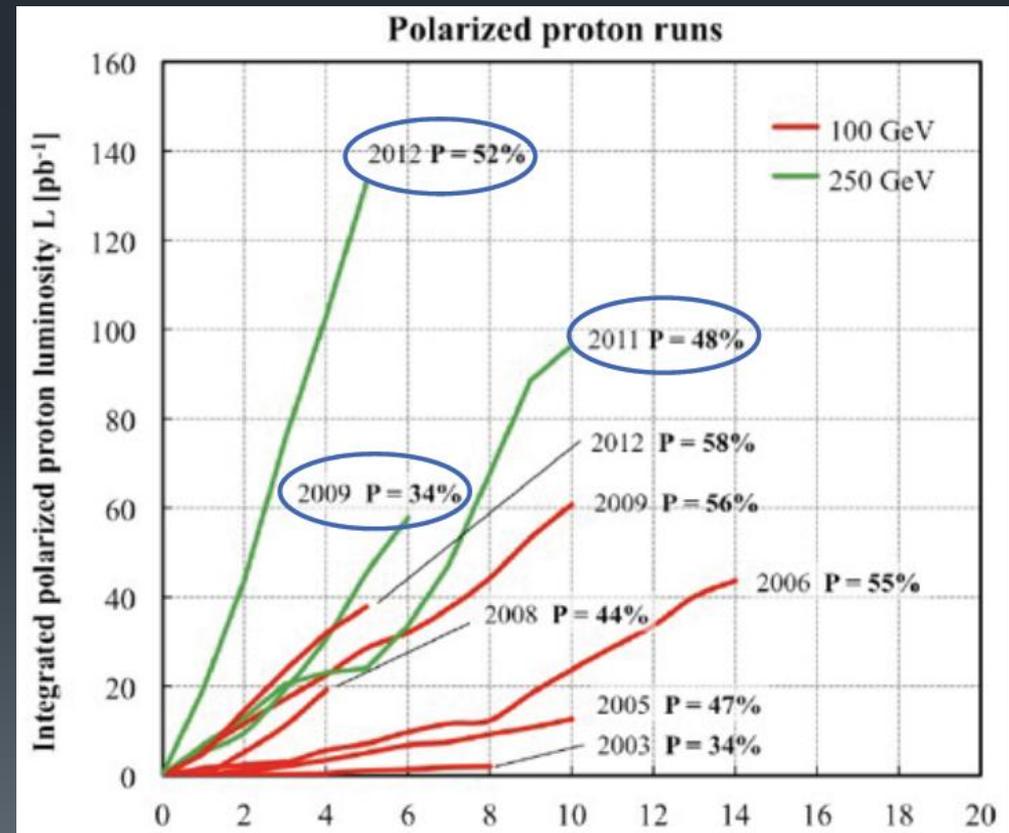
Polarized pp at RHIC

- Polarized pp collisions at $\sqrt{s}=200\text{-}500$ GeV
 - Longitudinal or transverse
- “Siberian Snakes”
 - Flip spin twice per rotation
 - Lessens depolarizing effects of accelerator
- Randomized spin direction per bunch
 - Alternating spin patterns give more consistent relative luminosity



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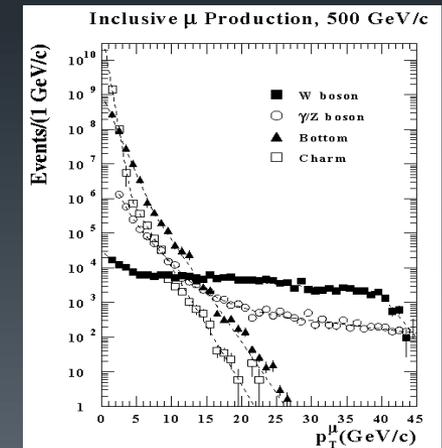
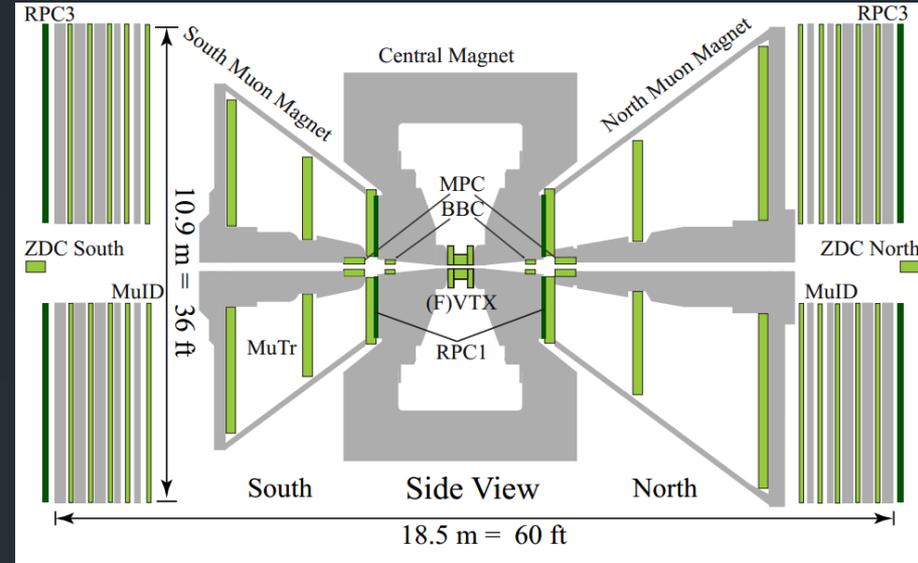


PHENIX Forward Muon Trigger Upgrade

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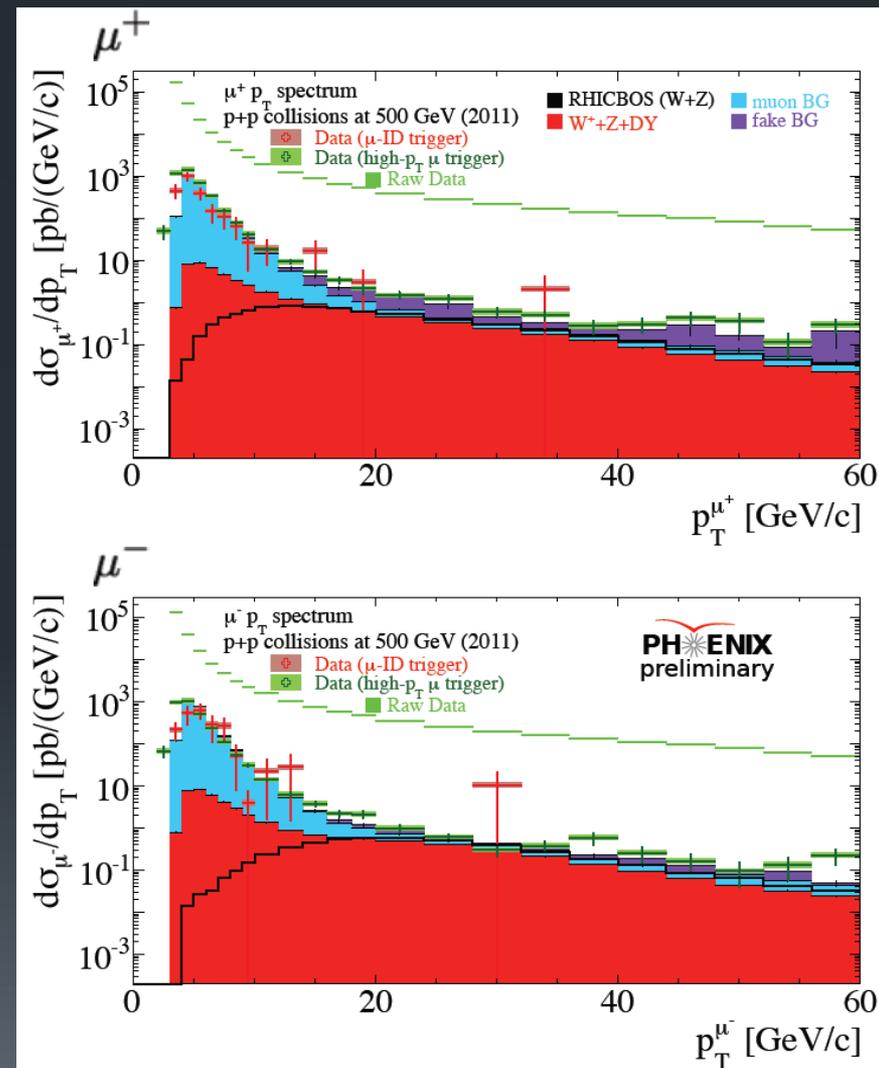
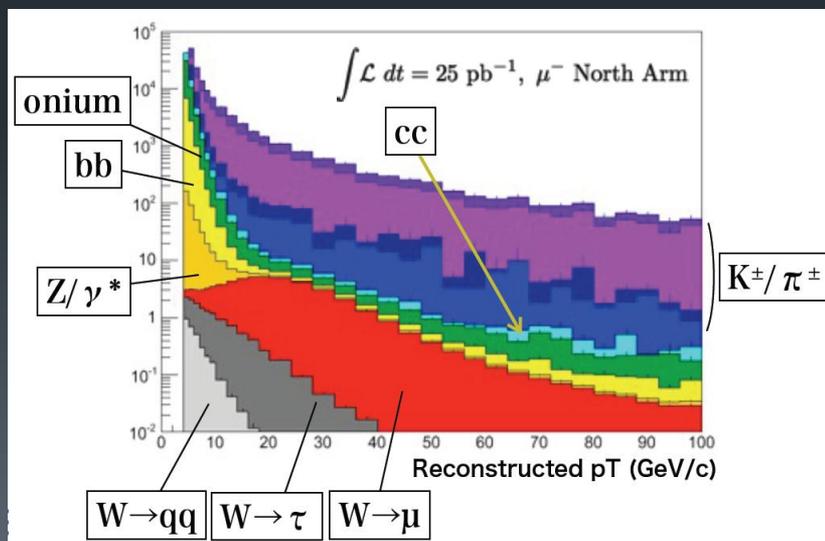
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- Experimental Challenge:
 - Trigger dominated by background especially at low p_T
- Solution:
 - Upgraded trigger system:
 - Tracking detectors now included in trigger allowing p_T discrimination
 - RPC detectors added
 - Precise timing rejects non-collision related background
 - Additional tracking point
 - New vertex tracker



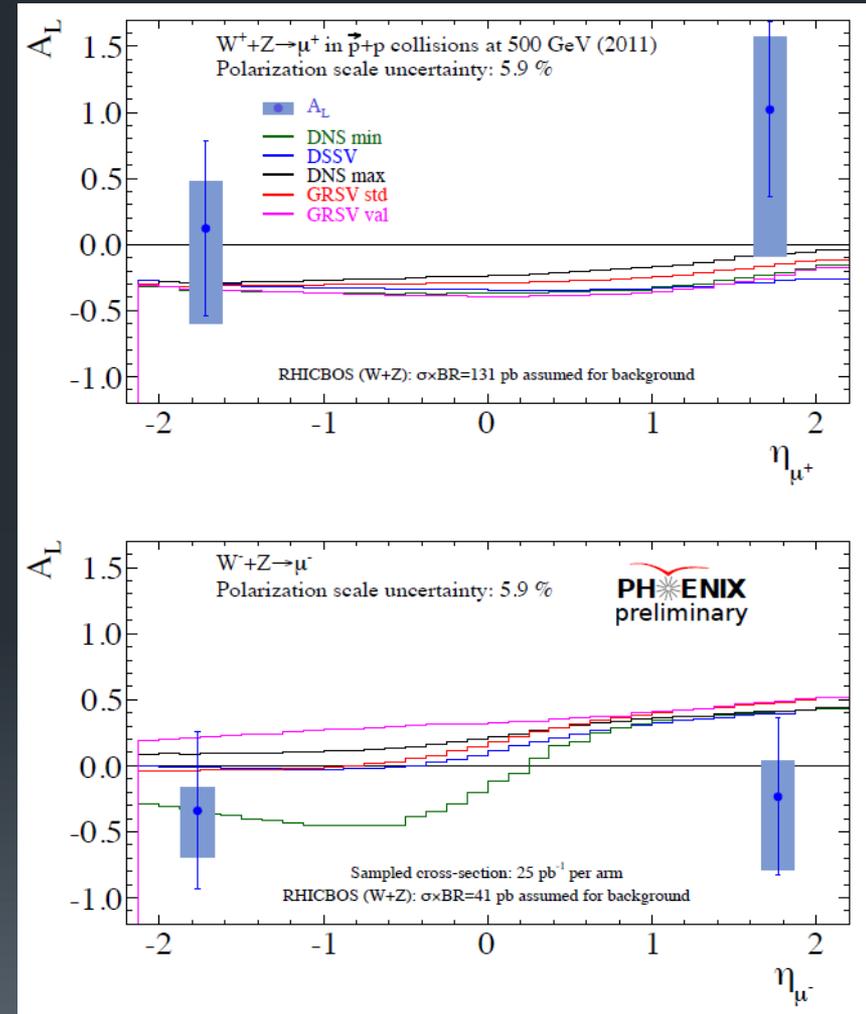
Signal Background and Simulations

- Simulations developed for 2011 analysis
- Accurate estimated background levels in simulation used for correction factor in real data



Initial Results

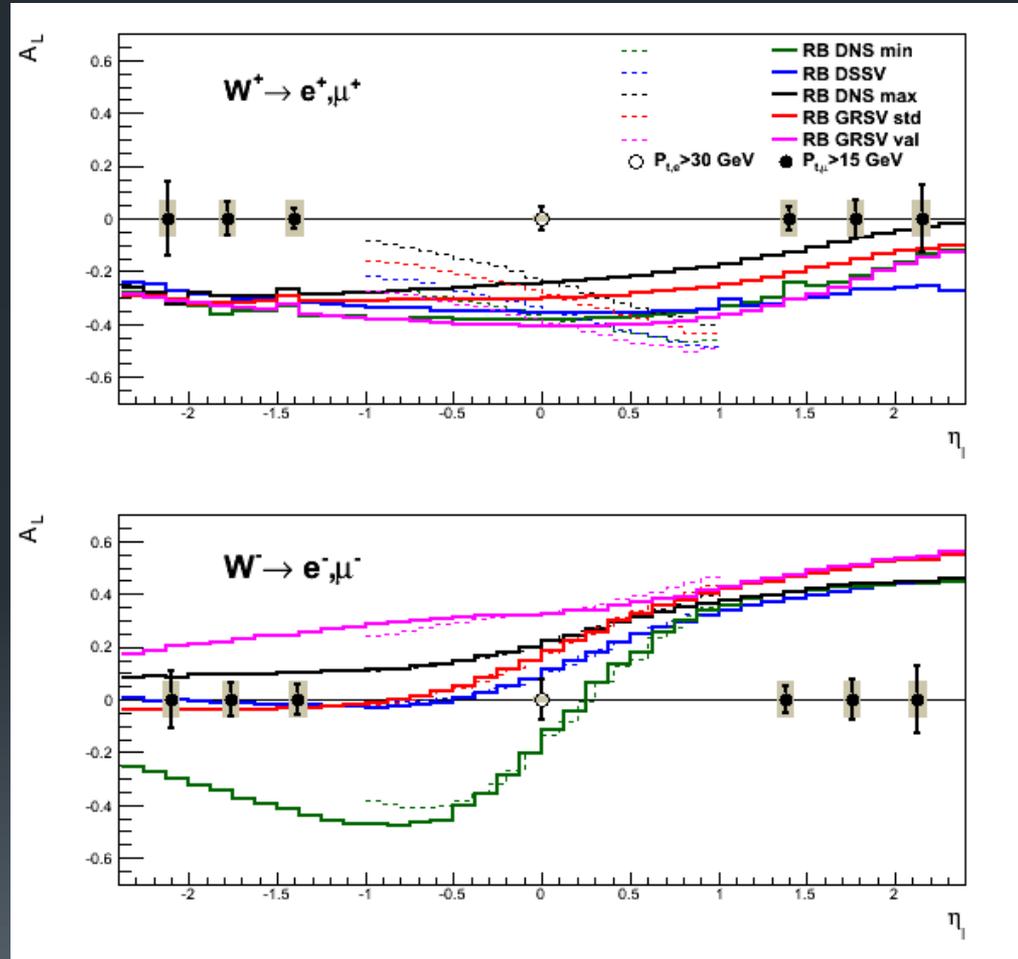
- 2011 Results
 - $\sim 25 \text{ pb}^{-1}$ Luminosity
 - $\sim 50\%$ Polarization
- 2012 Run: Analysis in progress
 - $\sim 50 \text{ pb}^{-1}$ Luminosity
- Largest portion of data will come from upcoming 2013 run



2011 run results

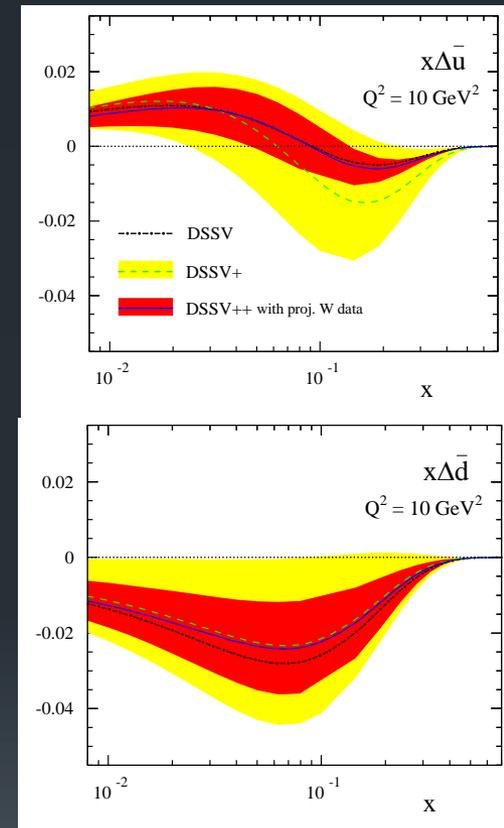
Projected Results

- Projection for 500 pb^{-1} delivered luminosity
 - ~55% polarization



Conclusion

- W Asymmetry offers a cleaner and more direct probe of sea quark spin
- PHENIX's forward upgrade is ready for $W \rightarrow \mu$ measurement
 - An analysis framework is in place
- 2013 statistics will make a significant contribution toward tighter constraints of $\Delta\bar{u}$, $\Delta\bar{d}$



Courtesy of Daniel de Florian, Rodolfo Sassot, Marco Stratmann, and Werner Vogelsang